

## WHAT IS CLAIMED IS:

1 1. A gear change control system of a belt-type continuously variable transmission,  
2 comprising:

3 I) a movable pulley piston chamber for causing a thrust force to a movable  
4 pulley which varies a groove width of each of a primary pulley and a secondary pulley, the  
5 movable pulley piston chamber having a double-piston constitution including:

6 a) a clamp chamber including a primary clamp chamber and a secondary  
7 clamp chamber, for causing a clamp force of clamping the belt, and

8 b) a cylinder chamber including a primary pulley cylinder chamber and a  
9 secondary pulley cylinder chamber, for causing a differential thrust force at a gear change;

10 II) a communication passage communicating the primary clamp chamber with the  
11 secondary clamp chamber, a clamp chamber's applied pressure area on a primary side  
12 being substantially equal to a clamp chamber's applied pressure area on a secondary side;

13 III) a gear change control valve for controlling an oil pressure of the cylinder  
14 chamber;

15 IV) a clamping force setting valve disposed between an oil pressure source and the  
16 communication passage, the clamping force setting valve setting an oil pressure of the  
17 clamp chamber; and

18 V) a gear change control section for achieving a certain gear change ratio by  
19 outputting an instruction signal to the gear change control valve and the clamping force  
20 setting valve in accordance with a sensed traveling state, the gear change control section  
21 including;

22 a) a primary thrust force calculating section for calculating a primary thrust  
23 force of the movable pulley on the primary side,

24 b) a secondary thrust force calculating section for calculating a secondary  
25 thrust force of the movable pulley on the secondary side,

26 c) a thrust force selecting section for selecting one of the primary thrust  
27 force and the secondary thrust force that is greater than the other, and

28 d) a clamp chamber oil pressure setting section for setting up a clamp  
29 chamber oil pressure by a following calculation:

30                   dividing the selected one of the primary thrust force and the secondary  
31 thrust force by an addition of:  
32                   the clamp chamber's applied pressure area of one of the primary  
33 clamp chamber and the secondary clamp chamber, and  
34                   a cylinder chamber's applied pressure area of the cylinder chamber  
35 on a selected side.

1     2.     The gear change control system of the belt-type continuously variable transmission,  
2 as claimed in claim 1,  
3         wherein  
4         the gear change control system further comprises:  
5         I)     an output torque sensing section for sensing an output torque of the belt-type  
6 continuously variable transmission,  
7         II)    an input torque converting section for obtaining a converted input torque from  
8 the sensed output torque, and  
9         III)   an input torque estimating section for obtaining an estimated input torque, and  
10        wherein  
11        when the converted input torque is over the estimated input torque, the clamp  
12 chamber oil pressure is set to be substantially maximized.

1     3.     The gear change control system of the belt-type continuously variable transmission,  
2 as claimed in claim 1,  
3         wherein  
4         the communication passage has an oil pressure sensor for sensing the oil pressure,  
5 and  
6         when a sensed actual clamp chamber oil pressure is greater than a clamp chamber  
7 setting oil pressure by a predetermined value, the clamp chamber oil pressure is set to be  
8 substantially maximized.

1     4.     The gear change control system of the belt-type continuously variable transmission,  
2 as claimed in claim 1,  
3         wherein

4 the gear change control system further comprises:

- 5 I) an actual gear ratio sensing section for sensing an actual gear change ratio, and  
6 II) a differential thrust force calculating section for calculating a deviation of the  
7 sensed actual gear change ratio from a target gear change ratio, and for calculating the  
8 differential thrust force between the primary thrust force and the secondary thrust force  
9 based on the calculated deviation, and

10 wherein

11 with a gear change instruction outputted, the gear change control section  
12 allows the clamp chamber oil pressure setting section to set up the clamp chamber oil  
13 pressure based on the thrust force which is obtained when the target gear change ratio is  
14 reached, and

15 a differential pressure capable of causing the calculated differential thrust  
16 force is caused by the cylinder chamber.

1 5. The gear change control system of the belt-type continuously variable transmission,  
2 as claimed in claim 2,

3 when the converted input torque is over a certain numeral times the estimated input  
4 torque, the clamp chamber oil pressure is set to be substantially maximized.

1 6. The gear change control system of the belt-type continuously variable transmission,  
2 as claimed in claim 5,

3 the certain numeral is in a range from 1.2 to 1.5.

1 7. The gear change control system of the belt-type continuously variable transmission,  
2 as claimed in claim 3,

3 wherein

4 the clamp chamber setting oil pressure is a target clamp chamber oil pressure.

1 8. The gear change control system of the belt-type continuously variable transmission,  
2 as claimed in claim 1,

3 wherein

4 the primary pulley cylinder chamber and the secondary pulley cylinder chamber  
5 have substantially the equal cylinder chamber's applied pressure area.

1 9. The gear change control system of the belt-type continuously variable transmission,  
2 as claimed in claim 8,  
3 wherein  
4 the primary thrust force is a force for the movable pulley on the primary side, while  
5 the secondary thrust force is a force for the movable pulley on the secondary side,  
6 the clamp chamber oil pressure is an oil pressure that is inputted to the primary  
7 clamp chamber and the secondary clamp chamber, and  
8 a primary pulley cylinder chamber oil pressure is inputted to the primary pulley  
9 cylinder chamber, and a secondary pulley cylinder chamber oil pressure is inputted to the  
10 secondary pulley cylinder chamber.

1 10. The gear change control system of the belt-type continuously variable transmission,  
2 as claimed in claim 9,  
3 wherein  
4 the primary thrust force and the secondary thrust force are given respectively by the  
5 following expression (A) and expression (B):

$$6 \quad F_{zp} = P_p \cdot A_{sft} + P_{cl} \cdot A_{cl} \quad \cdots \quad \text{Expression (A)}$$

$$7 \quad F_{zs} = P_s \cdot A_{sft} + P_{cl} \cdot A_{cl} \quad \cdots \quad \text{Expression (B)}$$

8 where:  $F_{zp}$  is the primary thrust force,  
9  $F_{zs}$  is the secondary thrust force,  
10  $P_p$  is the primary pulley cylinder chamber oil pressure,  
11  $P_s$  is the secondary pulley cylinder chamber oil pressure,  
12  $P_{cl}$  is the clamp chamber oil pressure,  
13  $A_{sft}$  is the cylinder chamber's applied pressure area of any one of  
14 the primary pulley cylinder chamber and the secondary pulley cylinder chamber, and  
15  $A_{cl}$  is the clamp chamber's applied pressure area of any one of the  
16 primary clamp chamber and the secondary clamp chamber,  
17 the cylinder chamber's applied pressure area and the clamp chamber's applied  
18 pressure area are substantially fixed, while the primary pulley cylinder chamber oil

19 pressure, the secondary pulley cylinder chamber oil pressure and the clamp chamber oil  
20 pressure are parameters,

21 for holding the certain gear change ratio with a discharge oil pressure from the oil  
22 pressure source which is an oil pump kept low, substantially a maximum oil pressure  
23 among the primary pulley cylinder chamber oil pressure, the secondary pulley cylinder  
24 chamber oil pressure and the clamp chamber oil pressure is to be substantially minimized,  
25 and

26 the primary thrust force and the secondary thrust force have substantially the equal  
27 clamp chamber oil pressure, thereby, an element of a difference between the primary  
28 pulley cylinder chamber oil pressure and the secondary pulley cylinder chamber oil  
29 pressure determines the differential thrust force.

1 11. The gear change control system of the belt-type continuously variable transmission,  
2 as claimed in claim 10,

3 wherein

4 changing the expression (A) and the expression (B) with  $P_p \cdot A_{sft} = Y_p$ ,  $P_s \cdot A_{sft} = Y_s$ ,  
5 and  $P_{cl} \cdot A_{cl} = X$  brings about the following expression (C) and expression (D):

6  $Y_p = -X + F_{zp}$  ... Expression (C)

7  $Y_s = -X + F_{zs}$  ... Expression (D),

8 a first assumption is made such that  $F_{zp} > F_{zs}$ , making the following case 1) and  
9 case 2):

10 case 1) in which the secondary thrust force which is the smaller thrust force is  
11 paid attention to:

12 for substantially minimizing the maximum oil pressure among the secondary pulley  
13 cylinder chamber oil pressure and the clamp chamber oil pressure,  $P_s = P_{cl}$  is determined,  
14 and  $X = X_s$  herein is defined,

15 since  $P_p > P_s$ , the primary pulley cylinder chamber oil pressure is maximized,  
16 thereby, maximizing one oil pressure out of three kinds of the oil pressures,

17 case 2) in which the primary thrust force which is the greater thrust force is paid  
18 attention to:

19 for substantially minimizing the maximum oil pressure among the primary pulley  
 20 cylinder chamber oil pressure and the clamp chamber oil pressure,  $P_p = P_{cl}$  is determined,  
 21 and  $X = X_p$  herein is defined,

22 since  $P_p > P_s$  and the secondary pulley cylinder chamber oil pressure is smaller than  
 23  $X_p$ , the primary pulley cylinder chamber oil pressure and the clamp chamber oil pressure  
 24 are maximized, thereby maximizing two kinds of the oil pressures out of the three kinds of  
 25 the oil pressures meets the minimizing of the maximum, and

26 the clamp chamber oil pressure is thereby calculated by the following expression  
 27 (E):

28 
$$P_{cl} = F_{zp} / (A_{sft} + A_{cl}) \quad \cdots \quad \text{Expression (E)}.$$

1 12. The gear change control system of the belt-type continuously variable transmission,  
 2 as claimed in claim 11,

3 wherein

4 when a second assumption is made such that  $F_{zp} < F_{zs}$ , the clamp chamber oil  
 5 pressure is calculated by the following expression (F):

6 
$$P_{cl} = F_{zs} / (A_{sft} + A_{cl}) \quad \cdots \quad \text{Expression (F)}.$$

1 13. The gear change control system of the belt-type continuously variable transmission,  
 2 as claimed in claim 12,

3 wherein

4 based on the greater one of the primary thrust force and the secondary thrust force,  
 5 the primary pulley cylinder chamber oil pressure of the primary pulley cylinder chamber,  
 6 the secondary pulley cylinder chamber oil pressure of the secondary pulley cylinder  
 7 chamber, the clamp chamber oil pressure of the primary clamp chamber and the clamp  
 8 chamber oil pressure of the secondary clamp chamber are substantially equalized, thereby  
 9 minimizing the maximum oil pressure of the three kinds of oil pressures.

1 14. A gear change control method of a belt-type continuously variable transmission  
 2 which includes: I) a movable pulley piston chamber for causing a thrust force to a  
 3 movable pulley which varies a groove width of each of a primary pulley and a secondary  
 4 pulley, the pulley piston chamber having a double-piston constitution including: a) a

5 clamp chamber including a primary clamp chamber and a secondary clamp chamber, for  
 6 causing a clamp force of clamping the belt, and b) a cylinder chamber including a primary  
 7 pulley cylinder chamber and a secondary pulley cylinder chamber, for causing a  
 8 differential thrust force at a gear change; II) a communication passage communicating the  
 9 primary clamp chamber with the secondary clamp chamber, a clamp chamber's applied  
 10 pressure area on a primary side being substantially equal to a clamp chamber's applied  
 11 pressure area on a secondary side; III) a gear change control valve for controlling an oil  
 12 pressure of the cylinder chamber; IV) a clamping force setting valve disposed between an  
 13 oil pressure source and the communication passage, the clamping force setting valve  
 14 setting an oil pressure of the clamp chamber; and V) a gear change control section for  
 15 achieving a certain gear change ratio by outputting an instruction signal to the gear change  
 16 control valve and the clamping force setting valve in accordance with a sensed traveling  
 17 state,

18 the gear change control method comprising:

19 a) a first step for calculating a primary thrust force of the movable pulley  
 20 on the primary side,

21 b) a second step for calculating a secondary thrust force of the movable  
 22 pulley on the secondary side,

23 c) a third step for selecting one of the primary thrust force and the  
 24 secondary thrust force that is greater than the other, and

25 d) a fourth step for setting up a clamp chamber oil pressure by a following  
 26 calculation:

27 dividing the selected one of the primary thrust force and the secondary  
 28 thrust force by an addition of:

29 the clamp chamber's applied pressure area of one of the primary  
 30 clamp chamber and the secondary clamp chamber, and

31 a cylinder chamber's applied pressure area of the cylinder chamber  
 32 on a selected side.

1 15. A gear change control system of a belt-type continuously variable transmission  
 2 which includes: I) a movable pulley piston chamber for causing a thrust force to a  
 3 movable pulley which varies a groove width of each of a primary pulley and a secondary

4 pulley, the pulley piston chamber having a double-piston constitution including: a) a  
5 clamp chamber including a primary clamp chamber and a secondary clamp chamber, for  
6 causing a clamp force of clamping the belt, and b) a cylinder chamber including a primary  
7 pulley cylinder chamber and a secondary pulley cylinder chamber, for causing a  
8 differential thrust force at a gear change; II) a communication passage communicating the  
9 primary clamp chamber with the secondary clamp chamber, a clamp chamber's applied  
10 pressure area on a primary side being substantially equal to a clamp chamber's applied  
11 pressure area on a secondary side; III) a gear change control valve for controlling an oil  
12 pressure of the cylinder chamber; IV) a clamping force setting valve disposed between an  
13 oil pressure source and the communication passage, the clamping force setting valve  
14 setting an oil pressure of the clamp chamber; and V) a gear change control section for  
15 achieving a certain gear change ratio by outputting an instruction signal to the gear change  
16 control valve and the clamping force setting valve in accordance with a sensed traveling  
17 state,

18 the gear change control system comprising:

19 a) a first means for calculating a primary thrust force of the movable pulley  
20 on the primary side,

21 b) a second means for calculating a secondary thrust force of the movable  
22 pulley on the secondary side,

23 c) a third means for selecting one of the primary thrust force and the  
24 secondary thrust force that is greater than the other, and

25 d) a fourth means for setting up a clamp chamber oil pressure by a  
26 following calculation:

27 dividing the selected one of the primary thrust force and the secondary  
28 thrust force by an addition of:

29 the clamp chamber's applied pressure area of one of the primary  
30 clamp chamber and the secondary clamp chamber, and

31 a cylinder chamber's applied pressure area of the cylinder chamber  
32 on a selected side.